A REVIEW OF AVAILABLE METEOROLOGICAL DATA REPRESENTATIVE OF THE URAVAN URANIUM MILL SITE VICINITY

PREPARED FOR

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GRAND JUNCTION, COLORADO

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1. INTRODUCTION

NUS Corporation (NUS) has reviewed the wind speed/wind direction data from the Union Carbide Uravan mill for the period July 1976 - June 1977. One objective of the review was to determine if the data were of sufficient validity to justify the reduction of the wind direction data to obtain values and, from this, to determine the hourly average stability class. The joint frequency distribution obtained from this effort would then be used in the UDAD dispersion model for sources within the valley.

A second objective was to determine whether the sources at the B-plant site should be modeled using the same meteorological data as for the valley sources or using Grand Junction data.

Upon receiving the data, it was found that the full year of data from both the valley and B-plant sites had been reduced and coded on an hourly basis. However, only the valley site frequency distribution had been reported in the ER. NUS, therefore, examined both data sets to assess the usefulness of performing any further data reduction to obtain stability class data and to assess the validty of the data at each site. The results of this evaluation are discussed below.

2. DATA EVALUATION

The reduced wind data from two Uravan sites were received by NUS from Union Carbide. The two sites were the Trailer site (located in the valley at an elevation around 5,000 feet) and the B-plant site (situated near the bottom of a tailings pile at an elevation of approximately 5,370 feet). This data had been reduced from strip charts and recorded on an hourly basis on computer coding sheets for the period from July 1, 1976 to June 30, 1977. A data recovery from each site was estimated based upon the amount of hours that each station was not experiencing either downtime or obviously suspicious wind speed data periods (i.e., periods where the wind speed was stuck at 1 mph for days or weeks at a time or a wind direction was reported with a zero wind speed) divided by 8,760 hours. The trailer and B-plant sites have approximately 78% and 62% data recovery, respectively. However, the actual data recovery may be much lower than the figures listed above as is discussed below.

Based upon the data from the Trailer site, the wind blew from the east to east-southeast approximately 50% to 60% of the time. The wind was more widely distributed to the south and southwest at the B-Plant site but the prevailing wind reflected the influence of the valley orientation from southeast to northwest. No wind rose was available for the B-Plant so the prevailing wind direction is based on a semi-quantitative review of the data only. Winter had the poorest data recovery for each site while autumn showed a strong bias toward calms for both the Trailer and B-Plant sites.

Wind speeds were below 3 mph approximately 50 percent of the time at the Trailer site and 33 percent of the time at the B-plant site. Since no routine scheduled maintenance took place for the wind instruments at either site, from the time of installation in 1974, the threshold for the cup anemometers during the collection period may actually have exceeded 3 mph. NUS experience is that the threshold of anemometers may degrade after only a few months of use unless the instruments are checked and properly maintained. During the July - December 1976 data collection period, approximately 750 hours of zero wind speed with wind direction values were reported from both sites while no zero wind speed values were recorded in the January - July 1977 period.

When wind speed exceeded 12 mph at each site during the same hour, wind directions were often within one 22½ degree sector of each other. However, at times the wind directions were 180 sector degrees apart. The wind variability could indicate that sources located on top of the mesa (approximately 600 feet above the valley floor) are influenced by the regional wind patterns while sources in the valley are influenced by drainage winds reflecting the orientation of the valley. The mean wind speed was approximately 4.5 mph at the Trailer site and 6 to 7 mph at the B-plant site.

In order to assess the validity of the valley data, comparisons were made with available wind data from the San Miguel site in Disappointment Valley and the Grand Junction National Weather Service site to determine if the high frequency of drainage winds at Uravan would be reasonable. The San Miguel site (at an elevation around 5,725 feet), located in a valley five miles wide and 25 miles long, is broader and less steep than the valley surrounding Uravan, although both valleys are oriented in a southeast to northwest direction. Grand Junction (at an elevation of approximately 4,600 feet) is part of the broad Grand Valley. Although the data periods did not coincide for either the San Miguel, Grand Junction, or Trailer sites, each site showed winds blowing from the west-northwest to north-northwest 20% to 25% of the time. The influence of downvalley drainage winds (east to south-southeast) at the Trailer site were not apparent at Grand Junction but did show up at San Miguel. The San Miguel site appeared to be strongly influenced by southwest winds unlike either the Grand Junction or Uravan sites. Because of the much lower data recovery at the B-Plant site it is not possible to draw firm conclusions as to the meteorology that occurs except to indicate that valley effects appear and that wind speeds are often higher than within the valley. An examination of the B-plant site layout revealed that the tailing piles which are about as high as the valley walls can effectively act as an extension of the valley walls. This would explain the apparent valley effects observed in the B-plant meteorology. Therefore, for B-plant sources the Trailer site data should be appropriate. For the tailing piles located

on top of the mesa, wind data from Grand Junction would probably be more applicable than Trailer site data since these would be exposed to a much more regional air flow pattern and associated higher wind speeds than the other sources. Wind rose data from the Trailer site (reported as a 12 month data collection period), San Miguel site (nine month data collection period), and Grand Junction (five year data collection period) are attached.

Stability classification data were available for the San Miguel and Grand Junction sites. Hourly stability data at San Miguel were derived from the σ_θ aproach while the Turner method was applied at Grand Junction. The two locations each reported over 40% of hours with "F" stability (very stable atmosphere). Diurnal conditions in the valley at Uravan could be expected to at least approach this frequency and possibly exceed it on an annual basis. Based upon a high frequency of low wind speeds occurring at the Trailer site, the frequency distribution would be much lower for "D" stability (neutral atmosphere) than at the other two sites (24% at San Miguel and 33% at Grand Junction, respectively).

The total frequency of "A" stability (most unstable atmosphere) at Grand Junction is only 2.2% compared with 21% at San Miguel. The frequency of "A" stability occurrences at the Trailer site would most likely approach or exceed that at San Miguel due to its location in a more narrow and deep valley.

3. Joint Frequency Distribution

The data evaluation concluded that the data was not sufficiently adequate to justify further analysis or to provide stability class information. Therefore, the ER method for merging Grand Junction stability class data with Uravan valley wind speed/wind direction data was followed to provide the required joint frequency distribution for the modeling effort for sources located within the valley. This approach was taken when it was realized that the worst case stable conditions which comprised 40% of the conditions at Grand Junction and at San Miguel should dominate the dispersion results. It was concluded that the frequency of stable conditions would probably be 40% to 50% at the Trailer site under drainage flow conditions.

The percent frequency occurrence of wind direction by wind speed category table (Table 2.7-3) in the Dames & Moore Uravan report was reconstructed for the Trailer site by stability class. To obtain an annual joint frequency distribution at the Trailer site for the July 1976 - June 1977 data period, the annual frequency of stability occurrence from Grand Junction, CO 1960 - 1964 data set are incorporated into the percent frequency occurrence wind direction and wind speed tables (Tables 1 -6). An annual frequency occurrence was compiled by summing the frequency occurrences for each stability class from all wind speed categories for all sectors (Table 7). The Turner

stability classification method (Table 8) was used as a guideline for assigning stability to various wind speed categories without regard to time of day, cloud cover, or solar radiation intensity since such information is not readily available. For example, wind speed category 0-1 m/sec included the total frequency of occurrence of both A (2.2%) and F (25.0%) stabilities, while wind speed categories 4-10 m/sec (16.49%) and 10 m/sec (0.32%) were designated as D stability (Table 9). Wind speed category 1-4 m/sec included all the C stability cases (14.0%), the remaining 16.18% of D stability, and the 2.77% and 3.85% frequency of occurrence of B and E stabilities, respectively. The remaining 8.29% of B stability and 11.54% of E stability were assigned to the 0-1 m/sec data.

The breakdown for B and E stabilities for windspeed categories 0-1 m/sec and 1-4 m/sec are as follows:

1) After assigning all A and F stability cases to wind speed category 0-1 m/sec., 19.97% of the annual average frequency of occurrence remained (47.25% - (2.21% + 25.07%) = 19.97%) (From Tables 1 and 6). Since the annual frequency for B stability was 11.0% and for E stability 15.3% at Grand Junction the following calculations were performed:

$$\frac{11.0\%}{11.0\% + 15.3\%} = 0.418; \quad 0.418 \times 0.1997 = 0.0835$$

8.35% frequency occurrence for B stability

$$\frac{15.3\%}{11.0\% + 15.3\%} = 0.582; \quad 0.582 \times 0.1997 = 0.1162$$

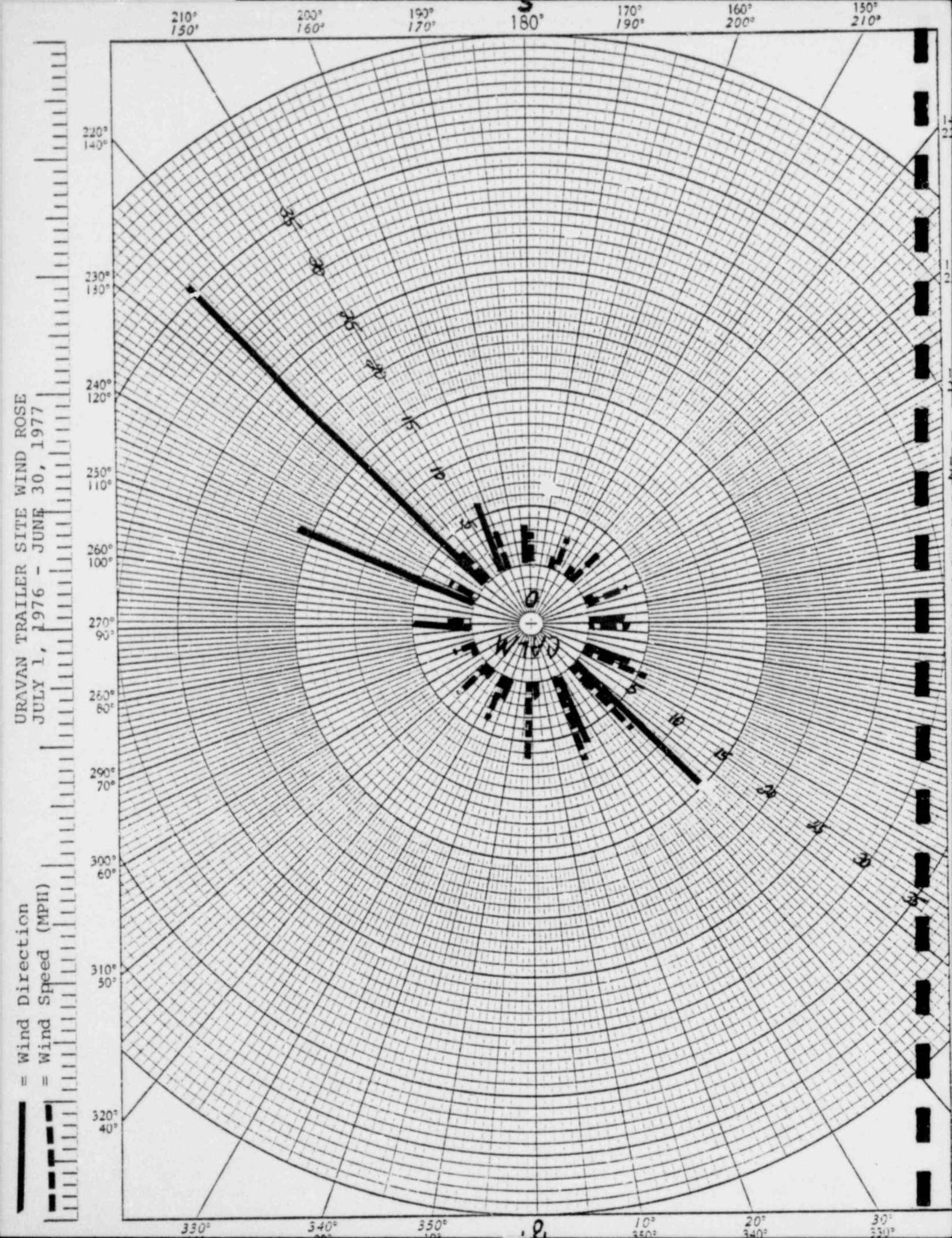
11.62% frequency occurrence for E stability

2) After assigning the entire C stability (14%) and 16.18% of the frequency of occurrence for D stability to wind speed category 1-4 m/sec, 6.63% of the annual frequency occurrence remained. (36.81% - (14.00% + 16.18%) = 6.63). (From Tables 3 and 4). Following procedures established above, the annual frequency occurrence of B and E stabilities for the 1-4 m/sec wind speed category are calculated below:

For B stability: $0.418 \times 0.0663 = 0.0277 = 2.77\%$
For E stability: $0.582 \times 0.0663 = 0.3858 = 3.86\%$

Although the Trailer site percent frequency occurrence of wind direction by wind speed category was reconstructed for each stability class, the frequency distribution for D stability (33%) at the Trailer site is much too high (possibly by a factor of 10) based upon the high frequency of low wind speeds occurring at that site as opposed to the Grand Junction site unless the anemometer was indeed not responding until the wind speed was much higher than the threshold of 3 mph. Furthermore,

the frequency of occurrence of A stability at the Trailer site would most likely exceed the 2.2% total reported at Grand Junction by at least a factor of 10 as seen in the San Miguel data due to its location in a much narrower and deeper valley. Therefore, long term stability data from Grand Junction (Table 10) for the neutral and unstable conditions are not really thought to be indicative of atmospheric stability conditions at the Trailer site for the July 1976 - June 1977 period. The frequency of stable conditions is expected to be similar to that at Grand Junction based on the comparison between San Miguel and Grand Junction. Because the stability classification is so dependent on wind speed which is suspect at the Trailer site, a more realistic site specific joint frequency distribution is not possible from the data available for analysis.


URAVAN TRAILER SITE WIND ROSE
JULY 1, 1976 - JUNE 30, 1977
= Wind Direction
= Wind Speed (MPH)
S
180°
210°
150°
200°
160°
190°
170°
170°
190°
160°
200°
150°
210°
220°
140°
230°
130°
240°
120°
250°
110°
260°
100°
270°
90°
280°
80°
290°
70°
300°
60°
310°
50°
320°
40°
330°
340°
350°
10°
20°
30°
CALM
0
5
10
15
20
25
30
35

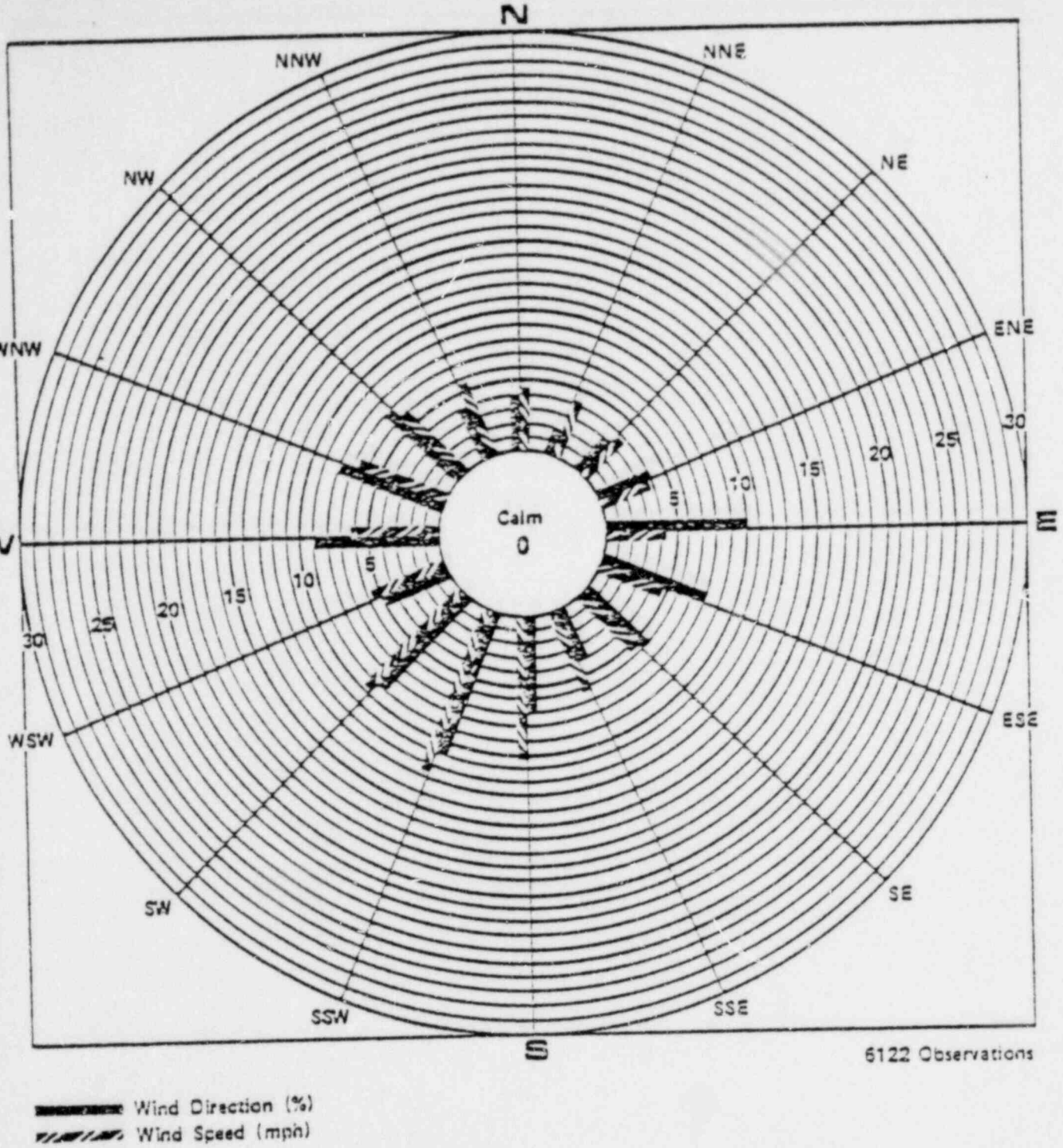


Figure 2.7—4 Annual San Miguel Wind Rose
(February 9, 1978 - November 17, 1978)

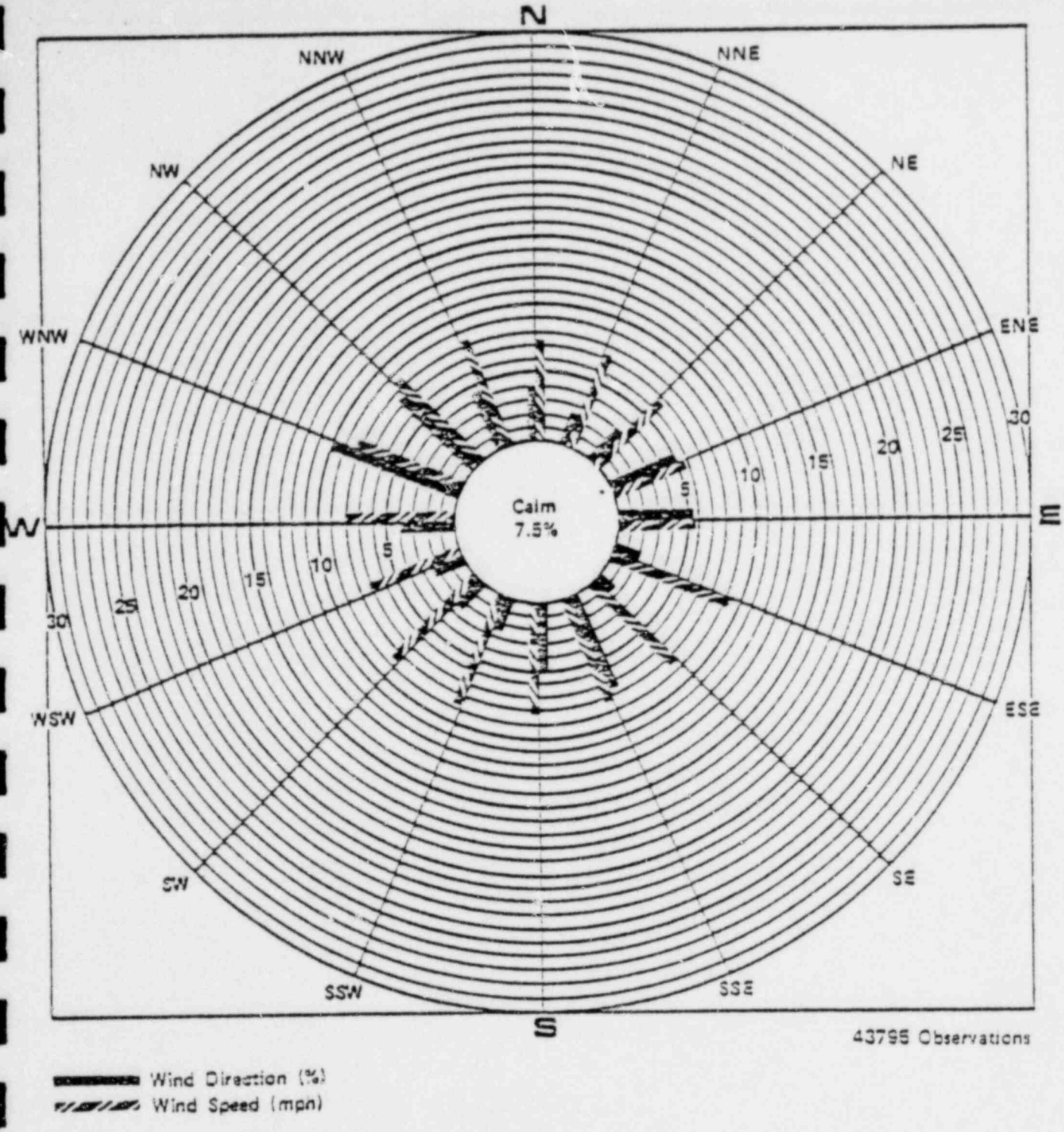


Figure 2.7–5 Annual Grand Junction Wind Rose (1960-1964)

TABLE 1

PERCENT FREQUENCY OCCURRENCE OF WIND DIRECTION BY WIND SPEED INTERVALS AND ASSOCIATED MEAN WIND SPEEDS FROM THE TRAILER SITE JULY 1976 THROUGH JUNE 1977

STABILITY CLASS A (MOST UNSTABLE)

WIND SPEED INTERVALS (m/sec)

	0-1	1-4	4-10	>10	TOTAL OCCURRENCE
N	0.01	0.00	0.00	0.00	0.01
NNE	0.04	0.00	0.00	0.00	0.04
NE	0.02	0.00	0.00	0.00	0.02
ENE	0.03	0.00	0.00	0.00	0.03
E	0.17	0.00	0.00	0.00	0.17
ESE	0.57	0.00	0.00	0.00	0.57
SE	0.86	0.00	0.00	0.00	0.86
SSE	0.14	0.00	0.00	0.00	0.14
S	0.09	0.00	0.00	0.00	0.09
SSW	0.01	0.00	0.00	0.00	0.01
SW	0.02	0.00	0.00	0.00	0.02
WSW	0.01	0.00	0.00	0.00	0.01
W	0.05	0.00	0.00	0.00	0.05
WNW	0.05	0.00	0.00	0.00	0.05
NW	0.10	0.00	0.00	0.00	0.10
NNW	0.04	0.00	0.00	0.00	0.04
TOTAL	2.21	0.00	0.00	0.00	2.21

TABLE 2

PERCENT FREQUENCY OCCURRENCE OF WIND DIRECTION BY WIND SPEED INTERVALS AND ASSOCIATED MEAN WIND SPEEDS FROM THE TRAILER SITE JULY 1976 THROUGH JUNE 1977

STABILITY CLASS B (MODERATELY UNSTABLE)

WIND SPEED INTERVALS (m/sec)

	0-1	1-4	4-10	> 10	TOTAL OCCURRENCE
N	0.04	0.05	0.00	0.00	0.09
NNE	0.14	0.07	0.00	0.00	0.21
NE	0.07	0.02	0.00	0.00	0.09
ENE	0.10	0.01	0.00	0.00	0.11
E	0.65	0.07	0.00	0.00	0.72
ESE	2.14	0.21	0.00	0.00	2.35
SE	3.25	0.93	0.00	0.00	4.18
SSE	0.52	0.22	0.00	0.00	0.74
S	0.35	0.08	0.00	0.00	0.43
SSW	0.04	0.02	0.00	0.00	0.06
SW	0.08	0.03	0.00	0.00	0.11
WSW	0.03	0.01	0.00	0.00	0.04
W	0.19	0.07	0.00	0.00	0,26
WNW	0.20	0.15	0.00	0.00	0.35
NW	0.36	0.58	0.00	0.00	0.94
NNW	0.13	0.25	0.00	0.00	0.38
TOTAL	8.29	2.77	0.00	0.00	11.06

TABLE 3

PERCENT FREQUENCY OCCURRENCE OF WIND DIRECTION BY WIND SPEED INTERVALS AND ASSOCIATED MEAN WIND SPEEDS FROM THE TRAILER SITE JULY 1976 THROUGH JUNE 1977

STABILITY CLASS C (SLIGHTLY UNSTABLE)

WIND SPEED INTERVALS (m/sec)

	0-1	1-4	4-10	> 10	TOTAL OCCURRENCE
N	0.00	0.25	0.00	0.00	0.25
NNE	0.00	0.34	0.00	0.00	0.34
NE	0.00	0.12	0.00	0.00	0.12
ENE	0.00	0.05	0.00	0.00	0.05
E	0.00	0.36	0.00	0.00	0.36
ESE	0.00	10.6	0.00	0.00	1.06
SE	0.00	4.69	0.00	0.00	4.69
SSE	0.00	1.11	0.00	0.00	1.11
S	0.00	0.41	0.00	0.00	0.41
SSW	0.00	0.11	0.00	0.00	0.11
SW	0.00	0.14	0.00	0.00	0.14
WSW	0.00	0.06	0.00	0.00	0.06
W	0.00	0.33	0.00	0.00	0.33
WNW	0.00	0.75	0.00	0.00	0.75
NW	0.00	2.93	0.00	0.00	2.93
NNW	0.00	1.28	0.00	0.00	1.28
TOTAL	0.00	13.99	0.00	0.00	13.99

TABLE 4

PERCENT FREQUENCY OCCURRENCE OF WIND DIRECTION BY WIND SPEED INTERVALS AND ASSOCIATED MEAN WIND SPEEDS FROM THE TRAILER SITE JULY 1977 THROUGH JUNE 1977

STABILITY CLASS D (NEUTRAL)

WIND SPEED INTERVALS (m/sec)

	0-1	1-4	4-10	> 10	TOTAL OCCURRENCE
N	0.00	0.25	0.00	0.00	0.25
NNE	0.00	0.40	0.19	0.00	0.59
NE	0.00	0.14	0.07	0.00	0.21
ENE	0.00	0.06	0.01	0.00	0.07
E	0.00	0.41	0.28	0.00	0.69
ESE	0.00	1.22	1.40	0.00	2.62
SE	0.00	5.43	4.98	0.06	10 47
SSE	0.00	1.28	0.32	0.00	1.60
S	0.00	0.47	0.13	0.00	0.60
SSW	0.00	0.13	0.01	0.00	0.14
SW	0.00	0.16	0.06	0.00	0.22
WSW	0.00	0.07	0.06	0.00	0.13
W	0.00	0.38	0.97	0.00	1.35
WNW	0.00	0.87	0.90	0.00	1.77
NW	0.00	3.39	4.87	0.19	8.45
NNW	0.00	1.48	1.94	0.07	3.49
TOTAL	0.00	16.18	16.49	0.32	32.99

TABLE 5

PERCENT FREQUENCY OCCURRENCE OF WIND DIRECTION BY WIND SPEED INTERVALS AND ASSOCIATED MEAN WIND SPEEDS FROM THE TRAILER SITE JULY 1976 THROUGH JUNE 1977

STABILITY CLASS E (STABLE)

WIND SPEED INTERVALS (m/sec)

	0-1	1-4	4-10	> 10	TOTAL OCCURRENCE
N	0.06	0.07	0.00	0.00	0.13
NNE	0.20	0.09	0.00	0.00	0.29
NE	0.10	0.03	0.00	0.00	0.13
ENE	0.14	0.01	0.00	0.00	0.15
E	0.91	0.10	0.00	0.00	1.01
ESE	2.97	0.29	0.00	0.00	3.26
SE	4.52	1.29	0.00	0.00	5.81
SSE	0.72	0.31	0.00	0.00	1.03
S	0.48	0.11	0.00	0.00	0.59
SSW	0.06	0.03	0.00	0.00	0.09
SW	0.11	0.04	0.00	0.00	0.15
WSW	0.04	0.02	0.00	0.00	0.06
W	0.26	0.09	0.00	0.00	0.35
WNW	0.28	0.21	0.00	0.00	0.49
NW	0.50	0.81	0.00	0.00	1.31
NNW	0.19	0.35	0.00	0.00	0.54
TOTAL	11.54	3.85	0.00	0.00	15.39

TABLE 6

PERCENT FREQUENCY OCCURRENCE OF WIND DIRECTION BY WIND SPEED INTERVALS AND ASSOCATED MEAN WIND SPEEDS FROM THE TRAILER SITE JULY 1976 THROUGH JUNE 1977

STABILITY CLASS F (MOST STABLE)

WIND SPEED INTERVALS (m/sec)

	0-1	1-4	4-10	> 10	TOTAL OCCURRENCE
N	0.11	0.00	0.00	0.00	0.11
NNE	0.45	0.00	0.00	0.00	0.45
NE	0.22	0.00	0.00	0.00	0.22
ENE	0.34	0.00	0.00	0.00	0.34
E	1.93	0.00	0.00	0.00	1.93
ESE	6.44	0.00	0.00	0.00	6.44
SE	9.80	0.00	0.00	0.00	9.80
SSE	1.59	0.00	0.00	0.00	1.59
S	1.02	0.00	0.00	0.00	1.02
SSW	0.11	0.00	0.00	0.00	0.11
SW	0.22	0.00	0.00	0.00	0.22
WSW	0.11	0.00	0.00	0.00	0.11
W	0.57	0.00	0.00	0.00	0.57
WNW	0.57	0.00	0.00	0.00	0.57
NW	1.14	0.00	0.00	0.00	1.14
NNW	0.45	0.00	0.00	0.00	0.45
TOTAL	25.07	0.00	0.00	0.00	25.07

TABLE 7

PERCENT FREQUENCY OCCURRENCE OF WIND DIRECTION BY WIND SPEED INTERVALS AND ASSOCIATED MEAN WIND SPEEDS FROM THE TRAILER SITE JULY 1976 THROUGH JUNE 1977

STABILITY CLASS = ANNUAL TOTAL
A - F

WIND SPEED INTERVALS (m/sec)

	0-1	1-4	4-10	> 10	TOTAL OCCURRENCE
N	0.22	0.66	0.30	0.00	1.18
NNE	0.83	0.90	0.19	0.00	1.92
NE	0.41	0.31	0.07	0.00	0.79
ENE	0.61	0.13	0.01	0.00	0.75
E	3.66	0.94	0.28	0.00	4.88
ESE	12.12	2.78	1.40	0.00	16.30
SE	18.43	12.34	4.98	0.06	35.81
SSE	2.97	2.92	0.32	0.00	6.21
S	1.94	1.07	0.13	0.00	3.14
SSW	0.22	0.29	0.01	0.00	0.52
SW	0.43	0.37	0.06	0.00	0.86
WSW	0.19	0.16	0.06	0.00	0.41
W	1.07	0.87	0.97	0.00	2.91
WNW	1.10	1.98	0.90	0.00	3.98
NW	2.10	7.71	4.87	0.19	14.87
NNW	0.81	3.35	1.94	0.07	6.17
TOTAL	47.11	36.78	16.49	0.32	100.70

TABLE 8

TURNER STABILITY METHOD

Surface Wind Speed at 10 m (m/sec)	Day			Night	
	Incoming Solar Radiation			Cloud Cover	Cloud Cover
	Strong	Moderate	Slight	>50%	<50%
<2	A	A-B	B		
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

TABLE 9

ADJUSTED TURNER STABILITY METHOD FOR APPLICATION OF GRAND JUNCTION 1960-1964 FREQUENCY OF STABILITY OCCURRENCE TO URAVAN TRAILER SITE PERCENT FREQUENCY OCCURRENCE OF WIND DIRECTION BY WIND SPEED CATEGORY

Surface Wind Speed (m/sec) Category	Stability Class(es) Applied
0-1	A,B,E,F
1-4	B,C,D,E
4-10	D
>10	D

TABLE 10

ANNUAL FREQUENCY OF STABILITY OCCURRENCE
(PERCENT) AT GRAND JUNCTION, CO
1960-1964

Annual Total	Stability Class					
	A	B	C	D	E	F
100.50	2.2	11.0	14.0	33.0	15.3	25.0

An example of a calculation that applies Grand Junction stability data to the Trailer site follows:

For ESE direction in the 0-1 m/sec wind speed category, percent frequency occurrence for A stability would be:

$$\frac{12.12\% \text{ (Table 7)}}{47.11\% \text{ (Table 7)}} \times 2.2\% \text{ (Table 10)} = 0.2572 \times 2.2 = 0.5658 = 0.57 \text{ (Table 1)}$$